UNIVERSITY OF TORONTO

The Provincial University of Ontario

Applied Science and Engineering

Aeronautic Training

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Mining Building, University of Toronto.

APPLIED SCIENCE AND ENGINEERING

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THE graduates of the University of Toronto from the Faculty of Applied Science and Engineering very well know that the part they play in the upbuilding and maintenance of Canada is indispensable. If one of them were asked, he would probably hesitate to admit this because, as a class, engineers are somewhat modest and reticent.

If graduates of other Faculties or if engineers' fellow-citizens in other walks of life, would have independent testimony of the indispensable nature of the engineering profession, they might read Rudyard Kipling's immortal poem "The Sons of Martha", which is the greatest eulogy of the services engineers contribute to their fellowmen that has yet been put into words.

The diversity of engineering runs the range of all the requirements of modern life and industry. The place engineering takes today demands the best type of our young men and the best that the University can turn out. They are demanded in all phases of our complex life and industry, which would well nigh cease if they who control, operate, and manage our utilities and great public services, were removed. Let us see how this is, and how it may apply to you.

This April morning of 1938 you rose bright and early and, if you live in Toronto, you bathed in fresh blue water from the Great Lakes, pumped up to you by huge pumps operated by electricity generated at Niagara Falls, ninety miles away. You shaved with hot water heated by the same electricity or by gas made from coal brought by rail or boat from Nova Scotia. All of this was done for you by engineers, civil, mechanical, and electrical—but this is just the beginning of the day.

You sat down to your breakfast at a table made of wood in a Canadian furniture factory, spread with a table cloth made probably of Irish linen and woven in a textile mill. You ate off tableware made of Canadian clay with metal utensils, the product of Canadian mines and manufactured in Canadian mills. Your cereal was originally from grain grown on

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Canadian farms, harvested with the latest agricultural equipment. transported by Canadian railways, stored in grain elevators and produced in Canadian cereal mills. Your bacon was produced in packing establishments and your bread in modern mechanical bakeries; you toasted it by gas or electricity. Your tea, coffee, milk, salt, sugar, and marmalade all passed through the hands of engineers at some stage of preparation. You read your morning paper made of our own spruce in Canadian paper mills and printed on huge electrically-driven machines at the rate of tens of thousands an hour. For all these at your breakfast table, you were indebted to mining, metallurgical, mechanical, ceramic, electrical, and chemical engineers.

You went down to business in a Canadian-made street car, running on rails produced in Canadian steel mills, laid in concrete on a great paved street, and propelled by electricity from Niagara Falls. If you have a motor car and can submit to growing downtown traffic and parking conditions, you utilized the services of civil, mechanical, electrical, metallurgical, and chemical engineers who provided the roadway and traffic lights, and put together the motor with its steel, nickel, chromium, copper, wood, leather, textiles, glass, and rubber, and provided the gasoline with which to propel it.

If you labour in a downtown office, you were taken up to the top floor of an office building, built by an architect and structural engineer, full of all kinds of mechanical and electrical devices, the first encountered being the high-speed elevator and the latest heating and air conditioning system. You sat down at a desk with steel fyling cabinets nearby, found telegrams awaiting you from Winnipeg and Vancouver, and were soon called by long distance telephone from Montreal. Then a special delivery boy from the post office handed in a letter flown from the West during the night by the Transcontinental Air Mail Service. In an adjoining room you heard the click of typewriters, and presently you were talking into a dictaphone for your morning correspondence. In all this you were continuously being served by mechanical and electrical engineers.

Between times during the morning you looked out of the windows, and in the foreground you saw blocks of industries and factories manufacturing innumerable articles used by Canadians, all supplied with electric power from Niagara Falls and the Ottawa River. You saw miles of railway sidings filled with cars containing Canadian products and a continuous movement of railway trains coming and going over the great

Canadian railway systems, built and maintained by three generations of civil and mechanical engineers.

If you looked further, out into Toronto Bay, you would have seen the new Toronto Harbour with its miles of docks and its Air Port now under construction on the Island. Further out and across the lake you also would have seen, if you could discern it, the huge newly constructed Welland Canal, which forms an important link in the ultimate St. Lawrence Waterway, the great national navigation and power project which is now so much under discussion—probably the next great public work to be undertaken by the country. In all this survey as well, you would have been looking at the work of hundreds of civil engineers, spread over the past two decades.

In due course after a busy day, you went home early to pack for a business trip to the North. Before dinner you sat for a while and listened to the radio news broadcast, and afterwards to a special Canadian programme coming jointly from Vancouver and Halifax, all produced by electrical engineers. You left on the night train to do some business the next few days in the busy mining towns of Northern Ontario. There you would expect to see the great gold, silver, copper, and nickel industries which have sprung up in the past thirty years, almost wholly the product of mining and metallurgical engineers. You may go farther northwards by aeroplane and if you do you will realize how you are being served by a new type of transportation engineer. Having seen you off on the train this April evening, however, you will have to disappear from this picture into the hands of the engineers who have built our railways and who are continuously working to keep them up to date.

Now to come back to the University. It will be more easy to realize what this great provincial centre of learning has done to help the country in educating and providing this army of applied scientists and engineers who have so admirably served their fellow-citizens.

There are nearly four thousand five hundred graduates in Engineering who have gone out from the University. They are scattered over Canada from coast to coast, are in various parts of the Empire and in many foreign countries. The leading part they have taken in Canadian development of railways, roads, canals, aerial transportation, hydro-electric power, mining, and metallurgy, and the mechanical and chemical industries, as well as in architecture and huge building construction, is so well known that they have made the professions of engineering and architecture synonymous with Canada's material progress.

There are now eight hundred and forty students in attendance in the Faculty of Applied Science and Engineering, training themselves to go out and help their predecessors in this great service for the country. "Helping" is the word to use in Canada; our forefathers showed us the way to help each other. That, too, is the spirit of the University of Toronto and of "School of Science" graduates, as they are still called; they all continue to help. If one should ask a graduate about that he would say "Yes, that is the 'School' spirit", and if one enquired further as to what he meant by the expression, he would say "Co-operation; service; helpfulness,—just that".

It is not hard to visualize what the next generation of young engineers will be doing, because if the curve of Canadian activity and development is projected for the next thirty years it will just keep on and on as it has in the past. That increasing volume of activity will most surely keep them busy and it will demand equally an increasing number of young men to carry on. It is more difficult, however, to visualize the diversity of their activities because more will be demanded of them. Who can tell what new things, what new discoveries, what new applications will arise during this next thirty-year period? How can we foresee what new regions of Canada will come into engineering activity, new industries into being, or older ones greatly expanded for new or additional production?

This is the picture that the rising generation of young engineers will now look at. There is no danger of their not being employed. The main question is how to train and prepare them for greatly diversified parts they will have to take. If this country has a reasonable increase in its activities and a steady growth, a proportional increase in the supply of engineers must be provided and they must be appropriately trained for the probable new trends.

The new generations coming on may form some idea of the profession into which they are going if they should choose engineering, but even with the imaginary picture which has already been presented, they may not feel sufficiently acquainted with the diverse nature of the main branches of engineering to enable them to choose fields for careers. It would be useful for them to have the picture filled in with more detail than is presented by the broad outline of a Toronto citizen's day.

Civil Engineering, the oldest and primary branch, mainly concerns construction and works outdoors and of large dimensions. In this field falls Municipal Engineering with its many subdivisions of Roadways, Water Supply, Drainage, and Town Planning; Highway Engineering, such as is represented in the great highway construction of the Province; Railway, Engineering, Navigation, Canal, Harbour, and Dock Engineering; Hydro-electric Power works, such as River Improvements, Dams. Canals, and Power Stations, and Structural Engineering embracing Bridges, Buildings, and other large steel or concrete structures. Today the civil engineer is rapidly being involved in air transportation, through the design and construction of airports and aeroplanes.

Architecture is, in some respects, similar to Civil Engineering, in that it deals with large buildings in their structural aspects and the two professions frequently work closely together. The Architect, while a designer and constructor of all kinds of buildings from houses to factories and sky-scrapers, now-a-days requires not only artistic sense along with the practical and a training in drawing, painting, and the technique of design, but a knowledge of the many special features which enter into modern buildings, the result of our present-day complex life. The School of Architecture lays stress upon practical work in vacations in architects' offices in preparation for this.

Mining Engineering, in its very nature, embraces civil, mechanical, and electrical engineering as well, in connection with underground workings, mining machinery and operation, milling and treatment of ores, assaying and administrative work in both engineering and industrial undertakings. The great mining industry demands for this a type of engineer who is prepared to lead a strenuous physical life outdoors and underground. Much practical work in and about the mines is essential to education in this field.

A new course in Mining Geology has been instituted at the University in this Faculty, designed to work somewhat in conjunction with Mining Engineering in so far as the geological features of the industry are concerned. It is not really an engineering course and its graduates cannot be called engineers. It, too, is a strenuous outdoor and underground calling.

The Metallurgical Engineer may be said to take on where the Mining Engineer leaves off, as he treats the ores and metals after the minerals are mined and prepared. He proceeds with the milling or concentration of the ores and the production of metals from them, refining and manufacturing them for commercial use in the form of steel, copper, nickel, and lead, together with their many alloys. It is he also, in conjunction with the mining engineer, who produces the gold bricks and silver ingots at our gold and silver mines. Another branch of the metallurgical field is that concerned with non-metallics, in which the Ceramic Engineer produces refractories, cement, heavy clay products, porcelain, glass and enamelled iron, as well as the commonly known ceramic articles.

Mechanical Engineering deals with a very diverse and extensive field. It is concerned with the production of power from coal, oil, and water and with its use in innumerable ways; it involves the design and manufacture of machinery for this purpose and its installation and operation. From the early water wheels and steam engines to the latest hydraulic and steam turbines, and from the earliest gas engine to the latest diesel, the mechanical engineer has been the one to apply these prime movers to power stations, locomotives, automobiles, and aeroplanes. The mechanical engineer designs and builds air compressors, aeroplanes, machine tools, pumps, refrigerating apparatus, heating and ventilating equipment, conveying plants and hundreds of industrial machines for manufacturing everything from hats to boots and from watches to automobiles.

Electrical Engineering, as the name indicates, includes all those phases of electric generation and its application in power, lighting, transportation, and communication which enter into modern life and industry. To enumerate all of them in detail would provide a lengthy list. Those on the industrial side alone, comprising electric motors, electric processes, electro-chemistry, and power-plant operation, form a very large field. Radio engineering has recently been absorbing many graduates into both the industry and the operation of radio systems.

Chemical Engineering has recently greatly increased as the country has become more industrialized. It is astonishing how many fields of manufacture now require the services of chemical engineers. In addition to the purely chemical industries engaged in the production of acids, alkalies, ammonia, chlorine and nitro products, there are numerous industries in which the chemical engineer plays a very important part. These industries comprise those of pulp and paper, rubber, paints and varnishes, petroleum and other oil products, coal tar derivatives, leather, brewing and industrial alcohol, sugar, salt, meats, and flour with its related products. As the name implies, an education in the combination of chemistry and engineering prepares a man to enter and become indispensable in these modern industries.

It is to be noted at this stage that mathematics is a very basic requisite in applied science. Engineering is full of it and no young man should enter the profession unless he likes and becomes proficient in mathematics, for he has constantly to live with and use that science. This is particularly so in the Civil, Mechanical, Electrical, and Chemical fields.

A new department, that of Engineering Physics, was recently established and the first graduates from it are going out this Spring. It is designed to give young men the basic training which will enable them to undertake research and investigational work, and it is thus for those whose interests lie rather in this than in routine design, production, supervision or management. This is a course of intensified application of mathematics and fundamental sciences related to engineering to a lesser degree. It remains to be seen whether and how this course will produce either a physicist-engineer or engineer-physicist. There will now always be a place in industry for a limited number of men of this type.

With respect to Research, this Faculty prosecutes it with much energy; this is natural because much of applied science is in the nature of research. This is recognized in some of the departments already described, especially in Chemical Enginering where most of the work in the Fourth Year is composed of research studies. Research in the broader fields is carried on by the School of Engineering Research, which in the past two decades has produced and published the results of over one hundred and fifty researches. These, together with independent reasearches by members of the Staff, have spread over a wide area such as:—steel and concrete bridge design, welded steel joints, seasoning of woods, ball-mill crushing processes, assaying, hydraulic turbine design, hydraulic power regulation, electric power control, electric transmission systems, heat insulation for buildings, chemical processes for numerous compounds in chemical industry, paper, silk weighting, dyeing problems, ceramics, aeroplane design, and architecture researches into early Canadian design and practice. A unique and very successful independent research prosecuted in these laboratories was the application of the delicate methods of ore separation in mining mills to the cleaning of seeds for agricultural uses.

While these brief descriptions of the various fields in engineering, for which preliminary education is provided at the University, may appear lengthy and impressive, it is to be remembered that there are increasing numbers of young men taking Applied Science who do not and never intend to follow engineering as a career. They take one of the courses for their acknowledged value and usefulness in fitting them to enter careers in the financial, business, or industrial life of the country. More than ever is this becoming recognized by "down town" business men and manufacturers, as well as by students and graduates themselves. That is why, in recent years, greater emphasis is laid on combining with the applied science subjects special instruction in Business, Economics and Finance, Management, Industrial Management, Cost Keeping, Commercial Law, Contracts and Specifications, Engineering Law, Engineering Economics, Architectural Economics, as well as Public Speaking.

It is recognized and acknowledged in many quarters that men with an applied science training, men with the "engineer-mind", are being sought for more than ever to take on administrative work and fill executive posts in our rapidly-changing industrial world and indeed in many businesses which are not at all related to the engineering profession. In this the oft repeated statement "The Engineer is by nature an Economist" is being borne out.

Mechanical Building, University of Toronto.

AERONAUTIC TRAINING

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THERE is increasing evidence that the opportunity offered by the future development of aviation has gripped the imagination of the young people of Canada. Unfortunately, at the present time many are being misled as to the nature of these opportunities and the training necessary to succeed in the airplane industry. Hardly a week goes by without some parent or young man asking the writer about what should be done in order to get into some branch of aviation; and it is with the object of giving certain information which will help to clarify the situation that this article is written.

May I first say that it has been recognized for some time past that Canadians have a peculiar flair for aviation. Back in 1908-09 two University of Toronto graduates, Baldwin and McCurdy, were among the first of the world's experimenters in that great period of awakening which preceded the Great War. Then again during the world war the number of Canadians who finally found their way into the Royal Air Force was remarkable. We have a great background of aviation history, the true meaning of which in world affairs has been and still is purposely obscured by those who fear its development.

For the purpose of this article, I propose to divide the whole industry into two parts, namely, the manufacture of planes and transportation operations.

If a man is to succeed in either of these branches of work, he must have a well developed sense of responsibility. Mere wish to "have a job" is not sufficient. There must be a sense of responsibility towards one's work which amounts to what might be called a professional pride.

If we analyse the character of the typical man found in the fabricating shop of an airplane factory, we find that he is a craftsman—a man with a deep interest in his work which he executes with extreme accuracy on his own initiative. The technical schools which have aeronautic courses provide an excellent training for the young men who wish to go into this type of work. It should be recognized, though, that this training has its limitations. If a man wishes to advance into the design office he must have very much higher educational qualifications.

The majority of young men who ask the writer about the industry wish to become designers, having in mind eventually to be able to take part in future developments. It is amazing the number who have been told that the proper procedure is to begin in the shop and then go into the design office when sufficient practical experience has been obtained. There is just enough truth in this advice to be dangerous. The procedure is correct provided a man has the proper engineering education. Rest assured, though, that all the shop experience in the world is of no value without the engineering education as far as becoming an airplane designer is concerned in these days of advanced technical investigation. Anything less than a thorough scientific training means that there is nothing more ahead in the design office than draughting on details which have already been designed by competent men.

The question as to what university training a man should obtain brings up a problem which must be faced honestly. The real question is not which branch of the ordinary recognized engineering courses such as civil, mechanical, electrical, etc., should be taken but rather, in which of the courses are the requisite subjects taught.

If a man wishes to become an airplane designer, there are certain requirements which his university course must fulfil. Cowley & Levy in their well known text "Aeronautics in Theory and Experiment" published in 1920, made the following prophetic statement: "Until comparatively recent times the engine was by far the most important element in the machine and the whole construction centred around it. Nowadays the internal combustion engine has been so far developed that its importance as a determining factor in the design of the airplane has diminished". The problem has since that time become increasingly one of aerodynamics and structural analysis. Therefore, the answer as to which course to take is to find the course which includes a thorough training in mathematics and physics, which will allow the requisite aerodynamics and will stress the analysis to be mastered.

At this point I am usually interrupted by the negative side with the statement: "Why, look at so and so. He was a graduate in the ordinary engineering course and now he is in the design office of Sarawak Specials doing splendid work!" The situation is perfectly true but not one to boast about. I happen to know the struggles of some of these men to master without help the necessary aerodynamics which they were unable to obtain at the university. It is a situation throughout the whole Dominion about which we in Canada have little reason to be proud.

To meet this situation the aeronautic training at the University of Toronto has been placed as an option in the course known as Engineering Physics. It is the only course that gives a mathematical training which enables a student to grasp fully the fundamentals of aerodynamics. And quite contrary to the impression sometimes unfortunately created, the content of engineering in the course is more than sufficient to cope with the very advanced structural analysis of airplane members.

If a young man has not the mathematical ability to enter such a course as outlined above, then he should keep away from design. I would also point out that he must have a practical sense as well; for no amount of mathematical ability alone will enable him to succeed.

I am often asked whether it is not possible to study in one of the ordinary engineering courses and then take postgraduate work in aeronautics. It has been done. I object to the process on the grounds that the necessary mathematical training should be given in logical order throughout the whole four years of one's undergraduate course. It is very difficult to make up the deficiency in one postgraduate year. The reason why this postgraduate idea has a foothold in Canada is because our universities in the past have not met the question of providing aeronautic training. I say this in the hope that graduates from the other Canadian universities may see it. There is no mystery in aeronautic training. All universities have men on their staffs who could give the fundamental work if they would only look into it. Probably the addition to the staff of one man who has some special interest in the matter is all that is needed to coordinate the efforts.

From the above, it is seen that the opportunities in design should be restricted to highly trained men. When this is pointed out to young men there is usually a glum pause. What can they do to get into this wonderful industry? But there is another side to the question which has not been properly recognized in Canada but which will come to the front more and more in the next two years.

If we look at the transportation side of the question, we find that the great demand in Canada in the near future will be for highly trained pilots, pilot navigators, despatchers, meteorologists, radio operators, etc. It is unfortunate that more information about this field of work has not been available. It is not grasped here in Canada that a transport pilot, for instance, must be a highly trained man in order to work with the large number of instruments now used. The mere flying of the plane is a very small part of the work. As I have heard it so aptly put by a well known flying man, "The pilot of an air liner compared with the pilot of an ordinary two or three seat plane is in very much the same category as the captain of an ocean liner compared with the captain of a ferry boat."

These transportation openings will call for men having at least two years' training above senior matriculation. On October 3rd, 1938, the University of Toronto commenced a two-year diploma course in Aerial Navigation which provides the required training. It is into this large operation field of endeavour that many young men will find their way.

I would state the whole case concisely by first advising all young men to obtain senior matriculation standing. This will give them a means of measuring their ability. If they do not wish to go farther with their school studies and they have a good technical school training, there are two good openings available; first, to go into the shop of an airplane factory and become a skilled airplane craftsman; and secondly, to work for a licence as a ground engineer. There will always be openings for these last-mentioned men who supervise and conduct the inspection of airplanes and engines on the ground. For those who wish to enter the transportation field, a two-year course of training should be taken after senior matriculation; and in speaking of this training I am thinking only of the time-scheduled large transport work. There is an opportunity for commercial work in the unscheduled field of side-line operation which has been so successful in our mining areas. The training for this has been carried on up to date largely through the medium of the Flying Clubs which deserve a great deal of credit for operating with no real encouragement. Then, finally, if a man has good mathematical qualifications, he may consider taking a course in engineering which will fit him for design work. I would also add to all of this that no matter which branch of the industry is chosen other than transport pilot, a young man should take out a private pilot's licence at least so that he will have some practical experience of aviation. It will always add strength to his position.

In conclusion, I wish to point out that none of this training will succeed unless the manufacturer and operator encourage the use of more highly trained men. If properly trained men cannot get employment in this country, they will go elswhere as they are doing. England is taking our men from us. Our first graduates this year with aeronautic training have been taken into the design offices of two of the largest airplane companies in England. Three undergraduates in the course have gone to England for the summer to work in English factories, finding their way over by cattle boat, etc., as they could not get work with the Canadian factories. I appreciate the problem of the Canadian manufacturers. They are beset by politicians and friends trying to get their young men into the airplane industry; and so we obstruct the road for future development. We learn slowly and painfully, but we do learn. I am hoping that our own graduates at large will see the point and help with the problem. After all, only as we raise the level of the average thinking of the people at large can we advance in any given public problem. In this case, it is vital that Canadians understand how we are being held back. The time is not far away when we may regret not having developed to its utmost our birthright of air-mindedness.

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